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INVESTIGATING TEMPORAL VARIATIONS IN STRESS FROM FOCAL MECHANISMS OF AFTERSHOCKS OF THE LOMA PRIETA EARTHQUAKE

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ABSTRACT

This study investigates the state of stress around the Loma Prieta rupture zone, as indicated by the focal mechanisms of more than 1800 aftershocks (compiled by the Northern California Earthquake Data Center), for a period of about four years following the mainshock of October 18, 1989. It is based on an established procedure for estimating four of the six numbers of the stress tensor from populations of well-constrained focal mechanisms (of sufficiently small space-time windows, such that the stress may be regarded as uniform among each population), assuming that the shear stress and slip direction are aligned on at least one of the two nodal planes of each focal mechanism. This follows earlier work which suggests a distinct pattern of spatial variation of stress from the first six weeks of aftershocks. The present effort refines the search for stress variations using the updated aftershock catalog of more than four years of seismicity. The stress field is investigated by assigning well-constrained focal mechanism data to bins defined by space and time, and performing independent inversions to estimate the four stress parameters on each data bin. By comparing results among the array of subsets it is possible to resolve meaningful stress variations through space and time.

The stresses indicated by the Loma Prieta aftershocks vary systematically in both space and time around the mainshock fault zone. Consistent with previous results from analysis of early aftershocks, the mainshock fault plane appears to be nearly relieved of shear stress to the NW of the hypocenter but remained loaded with shear stress to the SE. While among most of the subregions the local states of stress appear to have persisted for the few years following the mainshock, there is a distinct change in stress indicated at the SE end of the aftershock zone (extending to the creeping section of the San Andreas) over the four year period. This resolvable change in stress is indicated by only subtle variations in focal mechanism populations; these aftershocks seem to reflect repeated slip on weak planes of similar orientation under temporally varying stresses, thus yielding variable slip directions. Considering the best fitting stresses for each data subset at the SE end of the aftershock region, the predominant right lateral strike slip fault planes appear to experience a change from (orientations of) relatively high shear stress and intermediate normal stress to (orientations of) relatively low shear stress and high normal stress over this time period. In spite of this change from relatively favorable to unfavorable stress orientations, these planes continue to slip while ones of other (more favorable) orientations do not. These observations may indicate spatial variations in physical properties and temporal pore pressure effects associated with large earthquakes in well evolved fault zones, as proposed by others.